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ABSTRACT

A review of Piaget's theory and research on children's cognitive development is presented, including a discussion of the psychological structures of intelligence, developmental constructivism, and the evolution of knowledge as a subject-object relation. Piaget's assessment techniques are summarized, including moral development, number conservation, spatial operations, and a comparison between intelligence quotient and Piaget's assessment of intelligence. Implications of Piaget's theory for educational practice are discussed in terms of the need for research, recommendations for teacher education, educational objectives, and teaching methods. A guide to conducting Piagetian child assessments and a six-item annotated bibliography on Piagetian theory and testing are appended. A 50-item unannotated bibliography is also included. (MH)

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ERIC REPORT 68

The Educational Implications of Piaget's Theory and Assessment Techniques

by Richard De Lisi

ERIC® ERIC CLEARINGHOUSE ON TESTS, MEASUREMENT, & EVALUATION
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PREFACE

Many people find it difficult to tackle Piaget's own writings without prior introduction or clarification. This paper is meant to provide such an introduction. It should not be used to circumvent Piaget's books or the efforts of Piaget's many interpreters. In fact, the aim of this paper is just the opposite. It is hoped that the reader will discover the relevance of Piaget's work and be inspired to pursue matters in greater depth.

The reader should be cautioned that there can be major substantive differences between the writings of Piaget and "the Piagetians." For this reason, I have relied heavily on Piaget's own (translated) works in preparing this paper. My understanding of Piaget's writings has been shaped by the interpretations offered by Hans G. Furth and James Youniss.

Many of Piaget's books have had coauthors, hence the phrase "Piaget's writings" is frequently used when referring to the writings of Piaget and his collaborators, particularly B. Inhelder.

R. De Lisi

December 1979

INTRODUCTION

Jean Piaget's theory and research on cognitive development were rediscovered by American psychologists and educators in the 1960s (8,26,27). Since then, the number of articles and books on Piaget and education has increased dramatically as the field has undergone rapid transition.

According to Gallagher (16), there have been three phases in the attempts to apply Piaget's theory. The first phase consisted of introducing Piagetian tasks as curriculum materials. In the second phase, the implications of the concept of stages of development for classroom learning were explored. Phase 3 is a movement beyond the notion of stage and the use of other Piagetian constructs (such as equilibration) in the classroom. As a result of these efforts, Piaget's name is now widely recognized, but the theory is not widely understood because it is interpreted in so many ways (49).

This paper is intended for those educational practitioners and researchers who find themselves both curious and confused about Piaget's theory. Central aspects of the theory and assessment techniques and their relevance for educational practice and research are introduced. In addition, Piaget's own statements and ideas about education are summarized. These papers on education, which have been ignored for the most part, deal with applications at all levels of education (including university-level teacher training) so they are of potential interest to a wide variety of educators. The paper answers a basic question: Why should you, if you are involved in the field of education, be concerned with Piaget's theory?

WHY PIAGET AND EDUCATION?

In its broadest sense, education is a process of effecting progressive change in individuals. Education of children and adolescents addresses itself to various intellectual skills, social and moral values, knowledge of facts in specific areas, and so on. In an educational setting such as a classroom, teachers employ certain strategies and materials to "change" their students. This is usually thought of as adding to the students' knowledge base or increasing the students' skills.

The particular teacher strategy or method of instruction utilized in the classroom makes some assumptions about the "average" student and is based on a theory of how children learn or "change." This basis is often implicit, and perhaps even unconscious, as far as the classroom teacher is concerned. One teacher might use praise and gold stars with her students, another might try strict discipline and punishment, while a third teacher might group children on the basis of examination performance and use different techniques for each of the groups. The point is that educational practice makes assumptions about how much the "average" student knows and can learn, and is presumably using the most effective method to teach that student. Although classroom teachers certainly differ from each other, they all rely on certain principles of educational psychology such as theories of learning, measurement, origins of behavior and behavioral change, and so on.

Piaget has studied the process of change in children's thinking for approximately 60 years. His theory is the most comprehensive statement on intellectual development currently available to educational practitioners. Piaget has described the development of thinking from birth to late adolescence in areas that include logic, number, time, physical causality, space, geometry, perception, mental imagery, hypothesis testing, and consciousness. (This list is a partial one!) Thus, Piaget has described what the "average" child knows and, more importantly, how this knowing came about and how it will evolve further. These dual aspects—descriptions of what children know and how knowledge develops—are the reasons why Piaget's theory may be important for educational practice.

As mentioned in the introduction, the original interest in applying Piaget to education was based on the wealth of his assessments of the development of children's thinking. At the very least, he has offered new ways to assess children's thinking in several content areas, many of which are covered in school. However, a more important reason to "apply Piaget" comes from his theoretical principles of intellectual development. Piaget's developmental constructivism (defined in a subsequent section) offers an alternative basis for classroom practice that may be more appropriate for educating our children and adoles-

cents than current practices (25).

Piaget's principles are based on the results of 60 years of research with children and adolescents (as opposed to research with rats or pigeons) that focused on the development of knowledge (as opposed to ranges of test scores). Perhaps the most effective teaching will come from "knowing how knowing comes to be"(4). Although this does not necessarily mean that a teacher has to be an expert on Piaget (most teachers are not experts on learning theory), an awareness of basic facts and principles can alter a teacher's view of the child and classroom practice, and perhaps even facilitate the process of education (4).

Undoubtedly some educators are looking to Piaget's theory because they are dissatisfied with the current state of affairs. Many feel that the methods of instruction currently employed are not working, turn students off, or only reach a portion of those in the classroom. Some are searching for a "culture-free" intelligence test, as the use of standardized IQ measures has been questioned in the courts. Be forewarned. Piaget's theory of intelligence does apply to all children—humans from all cultures considered as a species—but any particular Piagetian measure is not culture-free. This will be explained in a subsequent section. In the search for alternatives in educational practice, many have discovered and have been convinced that Piaget offers some viable and important options.

This paper begins with an introduction to Piaget's theory and research, since an understanding of the theory will make the educational implications more convincing and apparent. The second half of the paper reviews the implications of Piaget's theory and assessment techniques for education. Other reviews of Piaget's work can be found in (19) and (20).

PIAGET'S THEORY AND RESEARCH

Background

Piaget's first scientific works were in the field of biology. Something of a child prodigy, his first paper, on observations of an albino sparrow, was published when he was 11 years old. He continued his work in biology and based his doctoral thesis on a study of mollusks. Piaget's work in biology led to an interest in the question of adaptation to the environment. Specifically, he wanted to understand the mechanisms by which organisms develop physical structures that enable them to adapt to their environment.

Piaget was also a student of philosophy. Questions pertaining to the nature

of human knowledge, especially logical thinking, were of interest to him. For example: How is scientific thinking possible? What does it mean to know something? Although Piaget was fascinated by these philosophical issues, he came to believe that philosophers would not be able to provide conclusive answers because of their speculative methods, and he soon became disenchanted with philosophy because of its nonempirical methodology (34).

These two fields, biology and philosophy, influenced Piaget's theory and research in several ways. He decided to seek answers to philosophical questions concerning the nature of logical thinking with scientific (empirical) methods. Specifically, Piaget turned to the study of children to answer epistemological questions concerning logical thinking. One of his profound insights was that in order to understand a phenomenon, one needs to understand how it develops or comes about. Thus, to understand adult logical thinking, Piaget decided to study its formation in children of various ages.

Piaget approached the study of human thinking in a manner consistent with his training in biology. He was interested in what was common to groups of children rather than how or whether one child differed from another. In other words, Piaget studied logical thinking, which all humans, considered as a biological species, are capable of, rather than individual differences. The reader will note the obvious contrast with Binet's approach to intelligence, which consisted of developing a test designed to identify those children who could not be expected to benefit from Parisian public education.

The combination of biology and philosophy eventually led Piaget to form a new discipline called genetic epistemology, which involved psychology only insofar as its testing methods were used with children. That is, the questions Piaget set out to answer were not derived from psychology although his work dealt with human thinking. His method was to investigate the origins of knowledge from the biological perspective of specifying how children develop psychological structures to adapt to our human environment. It will help the reader to better understand Piaget's theory and its potential educational implications if the origins of the questions, aims, and testing methods are clear. The next sections will outline the course of Piaget's work with children and review a few of the important theoretical perspectives derived from these investigations.

Sixty Years of Research

Misconceptions about Piaget's theory stem, in part, from the fact that the theory and terms have evolved over the past 60 years. Moreover, Piaget has written about many areas including biology, epistemology, logic, and education. Most revisions of the theory probably have been made by Piaget himself (32). In this section, some of the more important of these theoretical developments and revisions, which occurred from the 1920s to the present, are reviewed. The focus will be on Piaget's books, and the aim is to illustrate how the theory and testing methodology have evolved together.

In his initial investigations of children's thinking (1920s to early 1930s), Piaget used a method with which he later became dissatisfied. He attempted to uncover children's conceptions of events in the world (such as physical causality) and aspects of their lives (such as dreams or moral judgments) by asking them questions. The method of data collection was a flexible, one-to-one, verbal interview in which Piaget probed for the "why" of children's reasoning and not merely how much they knew. Piaget realized that his "clinical method" often led to lower levels of reasoning than children could evidence in real-life situations. He felt a need, therefore, to check his findings with naturalistic observations, no doubt a carry-over from his training as a biologist. Piaget defended his verbal approach as he felt that the patterns identified with interviews were an accurate reflection of what occurred in day-to-day, real-life functioning (30).

During this 1920s-1930s period, Piaget believed that language played an important role in the development of abstract levels of thought. Younger children's thinking was described as egocentric (not able to see their point of view in relation to other points of view), and the role of peer interaction in decentering thought and thereby advancing intellectual development was stressed. The consistency of his findings in several content areas convinced Piaget that there were stages in the development of thinking. However, the stages had wide age ranges and were not observed in all areas of thinking (30). Piaget speculated that the development of thinking is caused by something other than maturation or learning, and wrote of an internal, self-regulating factor called equilibration, which implied that development has its own "motivation."

With the birth of his own children, Piaget turned to a different method of collecting data—naturalistic observation and testing—and to the study of infant development. His detailed observations of infants are classics in that they are still generating research on infancy today. Piaget's study of infancy led him to discover that there was a practical or sensorimotor intelligence that developed during the first 12 to 16 months of life and preceded theoretical or symbolic intelligence. Although sensorimotor intelligence continues to develop past the age of 16 months, it was not studied by Piaget beyond infancy (49).

Observations of infant development convinced Piaget of the central role that action (overt movements and *internal coordination of movements*) plays in the development of intelligence. Sensorimotor intelligence is a practical knowledge present in higher-level animals as well as in human infants. That is, a baby knows an object in the environment only when acting on it. Piaget described a twofold development resulting from an infant's interaction with objects: (1) the baby's action patterns (schemes) become consolidated, coordinated, and interrelated; (2) the baby's ability to relate objects in the environment to other objects also becomes more coordinated. Piaget now states that the first is the source of adult logical thinking, while the second leads to knowledge of the physical properties of objects.

Although Piaget was observing infant behavior, he discussed the development of sensorimotor intelligence in terms of nonobservable "schemes." The consistent, repeatable, and generalizable behavior patterns observed were said to reflect underlying rules for behavior called "schemes." The sensorimotor schemes cannot be measured directly and they may not have a physiological location in the brain or body. Instead, the schemes are inferred from repeatable and generalizable behaviors and are developed through interaction with objects. Schemes confer meaning on objects and are not fully mature, from an adult point of view, right away. Thus, when a three-month-old baby is sucking on a rattle in his crib, that rattle is known as a "suckable," and we infer that the infant has a scheme for sucking. As additional schemes are formed, objects are known in different ways. In time, the baby will know that the rattle is also a "shakeable," "throwable," and so on. Thus, there is a mutual interaction between the baby and the environment. The infant organizes or makes sense of his experience with objects and events in the world, and this leads to the formation of schemes. Schemes, in turn, confer meaning on objects. Sensorimotor development leads to the first truly "psychological" concept—object permanence—during the second year of life. The baby has a scheme for "object" and knows that objects exist independently of his or her action on them.

Once Piaget discovered sensorimotor intelligence and the primacy of action, he had reached a turning point in both theory and methodology, as the foreword to *The Child's Conception of Number* (45 p. vii) clearly states:

> In our earlier books . . . we analyzed various verbal and conceptual aspects of the child's thought. Later on, we examined the beginnings of thought on the practical and sensori-motor planes. . . . It now remains, in order to determine the mechanisms that determine thought, to investigate how the sensori-motor scheme(s) of assimilating intelligence are organized in operational systems on the plane of thought. Beyond the child's verbal constructions, and in line with his practical activity, we now have to trace the development of the operations which will give rise to number and continuous quantities, to space, time, speed, etc.,

operations which, in these essential fields, lead from intuitive and egocentric prelogic to rational coordination that is both deductive and inductive.

In dealing with these new problems, appropriate methods must be used. We shall still keep our original procedure of free conversation with the child, conversation which is governed by the questions put, but which is compelled to follow the direction indicated by the child's spontaneous answers. Our investigation of sensori-motor intelligence has, however, shown us the necessity for actual manipulation of objects . . . conversation with the child is much more reliable and more fruitful when it is related to experiments made with adequate material, and when the child, instead of thinking in the void, is talking about actions he has just performed.

As the quoted passage indicates, Piaget's work from 1940 to 1960 focused on the development of logical thinking in many content areas from early childhood to late adolescence. The testing methods were modified along with the theory, and there was a movement away from purely verbal techniques as children were asked to reason about problems posed by the experimenter. The problems almost always consisted of concrete stimulus materials so Piaget could observe children's actions as well as record their verbalizations. Based on the work during this period, Piaget revised his theory to de-emphasize the role of language in thinking, and in its place, he stressed the fact that thinking is an action that begins at a practical level in infancy and is then recapitulated on a theoretical level. Thus, Piaget stated that formal logic (adolescent thinking) is more than a verbal logic (22) and even stated that his initial position on language was incorrect (31). In the various areas of logico-mathematical thinking, Piaget argued that there was an invariant sequence of stages that could be described in mathematical terms. Again, the age of stage attainment varied from child to child, but this question of individual differences was not of interest to Piaget.

In the period from 1960 to the present, Piaget, having described several aspects of logical thought, moved to other areas of thinking. Books were published on perception, mental imagery, memory, and consciousness. In response to criticisms, these studies of children were conducted on larger samples, utilized detailed methodological controls, and summarized data in frequency tables. During this period, Piaget also published books on philosophy, epistemology, education, and the relation between biology and knowledge. After 40 years of research, he finally felt comfortable in stating his position on the question he originally set out to answer!

Piaget has not, over the past 20 years, described younger children's thought as egocentric. Instead, he characterizes it as an inability to coordinate states and transformations (44). Stages of development are precisely defined and are found in some (logico-mathematical), but not all (such as perception and mental imagery), aspects of thinking (37). Formal operations, the final stage of

logical thinking described by Inhelder and Piaget (22), may only be developed in an individual's area of special aptitude or expertise (36). New lines of research on the dynamic relations between thinking structures have been conducted by Inhelder (21,24). Finally, Piaget has recently clarified the role of equilibration in the development of thinking (42).

We will return to this review of Piaget's lifetime of research when we discuss educational implications. The next section will present some of the key theoretical points that this work has demonstrated about the nature of human intelligence.

THEORETICAL THEMES

Psychological Structures of Intelligence

Structuralism is currently an important theoretical position in the physical and social sciences. For example, N. Chomsky has identified the syntactical structures (transformational grammar) of language, which are rules used by adults to understand and generate sentences. In anthropology, Levi-Strauss has identified structures that determine kinship relations in primitive tribes. In biology, Watson and Crick isolated the double helix structure of DNA, which may provide the key to our heredity. Finally, in the field of psychology, S. Freud wrote that our human personality consists of a three-part structure—id, ego, and superego. As for human intelligence, Piaget has argued that it, too, consists of structures.

According to B. B. Wolman, a mental structure is "a hypothetical construct which is believed to account for similarities or recurrence of behavior" (50). Although this definition is fairly straightforward, the concept of structure within Piagetian theory has been misunderstood. Piaget has commented that he is often asked whether the structures he writes about are in the mind of the child or only in the mind of Piaget. It is important to realize that psychological structures are not directly observable but, instead, are inferred from regularities in behavior. That is, numerous studies (cross-sectional and longitudinal) conducted on thousands of children across the world have replicated the sequences of behavior that Piaget has identified. Given this kind of evidence, it does not seem overly speculative to suggest that these structures are real psychological entities. They are rules for acting, and, as such, underlie or determine overt behavior. The child or adolescent is not aware of them and does not consciously strive to apply them. Their physiological basis, if there is one, has not been identified—they are not "in the brain." Again, the structures are inferred from regularities in behavior.

One of the consequences of describing intelligence in terms of structures can be illustrated by clarifying the idea that structures underlie overt behavior. Overt experience (such as classroom teaching) is filtered through the structures. In other words, a person understands a situation only to the extent that he or she has formed the appropriate structures. Thus, the same overt experience can be understood differently by two individuals if their level of structural development is different. Piaget has described the development of those intellectual structures that are common to humans considered as a whole. Structures that order the physical world, called concrete operations (such as classification, seriation, number, and spatial), and structures that allow us to reason hypothetically, called formal operations (such as combinatorial logic and proportionality) have been identified. In the next section, we will consider how the structures are formed. On this issue, Piaget's theory is unique.

Formation of Structures: Developmental Constructions

The statement was made that we develop structures that order the physical world. Typically, this statement connotes one of two positions. Either the structures are programmed by heredity and unfold via maturational processes, or they are acquired or learned on the basis of experience. These two processes, maturation and learning (of several varieties), are usually invoked to explain change in the behavior of living organisms, and either one could perhaps account for the formation of psychological structures. Piaget contends that there is a third process that subsumes both maturation and learning. This process is called development or developmental constructivism and, before defining it, we will see why Piaget has rejected explanations of structural formation based solely on either maturation or learning.

Since Piaget's theory is based on biological principles, and since children throughout the world attain concrete operations, it might appear that concrete operations are formed through maturation. According to Piaget, maturation implies that the structures exist in innate form and are present at birth, waiting to unfold after contact with the environment. Piaget stresses that the structures one can observe in infants (sensorimotor schemes) and the operations found at later ages are not present in any form at birth. Thus, the structures are not inherited. What is transmitted by heredity is the tendency to act and to coordinate these actions, and it is through these tendencies that the structures of our intelligence are formed. Maturation does play a role in structure formation; for example, maturation of the nervous system is necessary before certain sensorimotor coordinations are possible. But maturation alone cannot account for development in its entirety, since heredity can only provide possibilities and it is up to the child to actualize them (33).

On the other hand, since psychological structures are said to be formed on the basis of experience, one might suppose that learning could account for their formation. Piaget does not deny that human beings can learn, but he does not believe that learning can account for the formation of intellectual structures from birth to adolescence. A distinction is made between learning and development with the latter process invoked to explain structure formation.

Piaget views learning as a process whereby the organism (subject) is modified by contact with objects or persons in the environment. The process is a passive one in the direction of object→subject. This empiricistic view holds that knowledge resides in an organized environment and is copied or learned by children. Piaget points out that although experience is clearly necessary for the formation of our intellectual structures, a child cannot be modified in every way at every point in time. Instead, it is the child who organizes the environment, rather than vice versa. In this perspective, objects in the environment are frontiers to be conquered or overcome by a process of successive approximations.

So our intelligence or knowledge of objects and events is based on experiences in which the child organizes or abstracts rules from interactions with objects. This organization takes two forms—logico-mathematical abstraction and physical abstraction. Logico-mathematical abstraction is a process of coordinating the results of the child's actions on objects—general actions such as uniting, ordering, or setting up of correspondences. These actions are found in all intelligent behavior, and their development occurs irrespective of which particular objects are present in the environment. It is this abstraction or coordination of the child's actions that leads to adult intellectual structures (logical thinking). Physical abstraction is a process in which the child acquires knowledge of specific objects' properties from experience or action on them. It is a process of abstraction from actions on objects. The distinction between logico-mathematical and physical abstraction is a theoretical one (11). In practice, we can only observe a child acting on objects in the environment. Piaget's view of developmental constructions, which holds that internal coordination of actions form structures which "know" or work in the environment, is summarized in Figure 1.

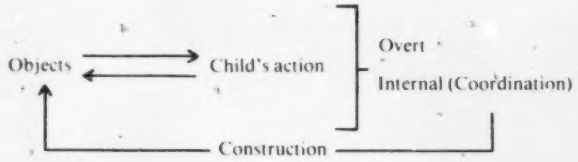


Figure 1. Developmental Constructivism

While it is difficult to prove that there is a process called "development" that differs from both maturation and learning, research findings do provide some indirect evidence to support this idea. The formation of Piagetian structures is more than a matter of maturation since research shows that type of experience is clearly a factor. For example, formal operations may only be developed in specific kinds of social environments that are intellectually challenging. Attainment of concrete operations occurs within wide age ranges from subject to subject and from one culture to another. Thus, specific experience does have an effect on development in terms of age of onset. On the other hand, research conducted in the 1960s attempted to speed up or enhance the development of children's intellectual structures. The results of these "training" studies were, for the most part, negative in that consistent and generalizable concrete operational reasoning was not effected in young children for long periods of time. Thus, the formation of knowing structures does take time, is based on experience, and is a gradual process that involves more than learning or direct tuition.

Knowledge as a Subject-Object Relation: Stages

We can now summarize Piaget's definition of knowledge. For Piaget, knowledge is not a static entity residing in the environment to be copied or learned or imposed on a passive knower. However, knowledge also does not exist independently of experience, in innate forms at birth waiting to unfold in a maturational manner.

Piaget has rejected an empiricistic and an idealistic view of intelligence and has stated that knowledge is a continually developing relation between subject (child) and object (environment). To describe knowledge, you start with this fundamental biological unit of subject=object and should not consider either the subject or the object independently (41). This view of knowledge as a relation is another way of saying that intellectual development is stage-like. Each stage is a summary term for a qualitatively different subject=object relation.

At birth, the neonate and the environment are undifferentiated as far as the neonate is concerned. Sensorimotor schemes and their eventual interrelation give rise to a practical know-how in which objects are known only when they are being acted upon. It takes approximately one to one-and-one-half years for the first theoretical concept to be developed—the permanent-object concept. This developmental construction provides the first break between subject and object. The infant now knows that objects exist independently of action on them. However, this theoretical concept only marks the beginning of a new subject=object relation. The child must now coordinate his or her actions on objects and relate objects to each other on a theoretical plane. The internal

schemes now underlie internal as well as overt actions. At first, the child's ability is marked by a failure to coordinate actions in a logical fashion (preoperational thinking). With development, actions are coordinated and stable theoretical concepts are formed (concrete operational thinking). The final stage of logical thinking, formal operations, is characterized by a subject=object relation in which the child can do more than order the physical world. Formal thought is hypothetical and deductive, with reality subordinated to possibility.

The preceding sections have summarized several aspects of Piaget's theory and research. In subsequent sections, the focus will shift to educational implications of this work. Applications of research findings and theoretical principles as well as Piaget's own statements about education will be presented. The next section will describe three areas of research conducted by Piaget and his collaborators. The research examples will clarify the points already made and will illustrate the potential of Piaget's findings for education.

PIAGET'S ASSESSMENT TECHNIQUES

Overview

Several points about Piaget's method of assessing children's thinking have already been made: (1) a wide age range of subjects, neonate to late adolescence, has been tested; (2) tasks have been devised to assess conceptions in many content areas; (3) the aim of the procedure is to discover not only how much a child knows or can do, but why the child reasons in the manner that she/he does; (4) children are assessed individually; and (5) the methods have varied from purely verbal interviews to naturalistic observation and testing to concrete problem solving with verbal probes. Appendix A contains a guide to conducting Piagetian child assessments.

Results obtained with these techniques are usually summarized in terms of stages or levels of performance. That is, responses that are conceptually similar (in success and errors) are grouped and presented together. To the best of my knowledge, Piaget has never assigned numbers and computed statistics on these observations. In recent years, he has tested larger numbers of children and summarized findings in frequency tables (23,44). However, Piaget's testing method has always included careful probing and counter-examples as ways to uncover the child's best possible performance. Despite the absence of statistics, Piaget's findings have been among the most reliable in the field of psychology (14).

The three examples presented below were chosen arbitrarily and do not, in

any way, summarize Piaget's findings on children's thinking. The examples demonstrate two of the testing techniques and deal with an age range of 5 to 11 years. They are presented to illustrate the point that children reason in a fashion which is qualitatively different from that of adults.

Moral Judgment

How does the mature moral reasoning of adults come about? Piaget (30) addressed this question in 1932 by studying the moral judgments of children aged 5 to 13 years. Verbal interviews were conducted on the rules of games, lying, stealing, punishment, responsibility, and justice.

Piaget concluded that there were two types of moral reasoning that were based on two types of social relations. Younger children evidenced a morality based on unilateral respect for rules imposed by authority figures. This morality was viewed as a consequence of the parent-child relationship. Older children evidenced a morality based on mutual respect, reciprocity, and cooperation between equals. This morality was seen as a consequence of peer-peer relations.

Let us examine what these conclusions were based on. Piaget found that younger children's prelogical thinking mechanisms (egocentrism) coupled with the rules imposed by adults led them to be moral "realists." That is, they focused on observable events and did not consider intentions in their judgments. Consider the following example (30, p. 148) in which two stories, each of which contained a lie, were read to a group of children. In story A, there is no evil intention, but there is a clear inaccuracy. In story B, the content is believable, but the intention is deceptive.

Story A A little boy (or a little girl) goes for a walk in the street and meets a big dog who frightens him very much. So then he goes home and tells his mother he has seen a dog that was as big as a cow.

Story B A child comes home from school and tells his mother that the teacher had given him good marks, but it was not true. The teacher had given him no marks at all, either good or bad. Then his mother was very pleased and rewarded him.

After checking to see that his 6- to 10-year-old subjects understood and recalled each story, Piaget asked them to compare the stories. The children were asked to judge which of the two lies or which of the two boys was naughtier and to explain why.

At one level of moral reasoning, more frequently characteristic of younger children, the child in story A was judged naughtier. The reasons given centered around the point that the more a lie departs from reality—the more unlikely it

is—the worse or naughtier it is. In contrast, at the next level of moral reasoning, intentionality was the basis for judgment. Thus, the child in story B was naughtier since he attempted to deceive his mother.

Piaget argued that younger children interpret the rigid rule systems of adults in a literal manner. That is, intentions are not important, since responsibility depends on whether or not a law has been respected or violated. It is only when placed in the company of his peers, in cooperative relations, that the child will consider intentionality. At that point, he is on his own and forced to consider other points of view.

Based on these kinds of data, Piaget reached a conclusion that is somewhat surprising and nonintuitive. Rule systems imposed on younger children by authority figures tend to slow down rather than promote the growth of moral judgments in children. He concluded that ". . . in order to really socialize the child, cooperation is necessary, for it alone will succeed in delivering him from the mystical power of the world of the adult" (30, p. 402).

Number Conservation

Piaget and Szeminska (45) demonstrated that between the ages of four and seven years children develop a stable and logical concept of number. A teacher who attempts to instruct young children in basic arithmetic operations (addition or subtraction) might be interested in these findings. The qualitative numerical structures identified by Piaget and Szeminska form a necessary basis for subsequent quantitative operations. Consider the following procedure which tests for knowledge of one-to-one correspondence and number conservation.

The child being tested sees six pennies (the number and material can be varied) spread out in a row on a table top. He is told by the experimenter that they are for his friend (or sibling) to take to the store (circus, and so on). The child is asked to reach into a bag of pennies and select the same number his friend has. Then the child is asked to place the pennies he selects on the table, in a row, until he has the same number as his friend.

Three levels of performance were observed. Children at the lowest level could not construct a row with an equal number of pennies. Instead, they matched the end points of both rows and believed that this led to an equal number of pennies in each row. For example, some children would squeeze 10 pennies together, and others would spread four pennies out. At the next level, children could construct a one-to-one correspondence that matched in number as well as length. However, after the experimenter spread out (or condensed) one of the rows, the children judged that the longer row now had more pennies. It is important to note that these children could count six in each row,

and they still did not conserve number. Instead, they confused spatial extension with number. At the final level of performance, children could construct an equal row and judged that they remained equivalent regardless of their spatial extensions.

Based on results such as these, Piaget and Szeminska argued that only the level-3 child has a stable number concept. This implies that the child is able to mentally decompose and recompose units. In the above problem, the child has to mentally coordinate the relation between the length of the rows and the intervals between the pennies in order to conserve number (six, in this case). It is precisely this operation (mental, reversible action) that the level-1 and level-2 children lacked. At levels 1 and 2, number is confused with spatial extension.

From this perspective, one can question the value of having young children memcrize mathematical tables. If a child is at level 1 or 2, can count, and is taught "2 + 4 = 6," does the child understand what she is learning? Such a child, if asked what 4 + 2 is, might respond that she does not know since she has not learned the 4 table yet. The point is that memorizing verbal equations may represent a knowledge of the number system that is at too high a level and hence not meaningful for the child (15). This example illustrates the difference between learning (arithmetic tables) and development (of number concepts) discussed in a previous section. Piaget's theory points to the differences between the acquisition of isolated pieces of information (recall of phrase "2 + 4 = 6") and the acquisition of a stable framework (number operation) which children in most cultures develop by six years of age.

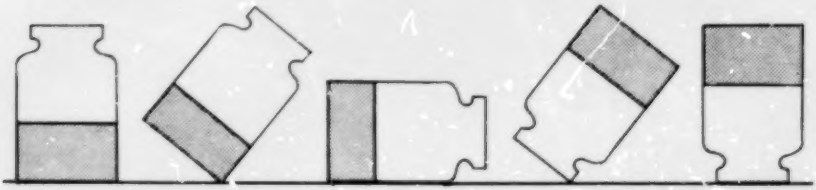
Spatial Operations

At what age would you guess children to be capable of ordering or representing space with horizontal and vertical axes? Our western world has an abundance of horizontal and vertical cues in the environment, which children can perceive at a very young age. Piaget and Inhelder's (43) experiments on spatial operations demonstrated that accurate perception and representation of the horizontal are separated by a number of years in the course of child development. They found that during the age span of 5 to 10 years, children evidence a stage-like sequence of performance in representing the horizontal coordinate.

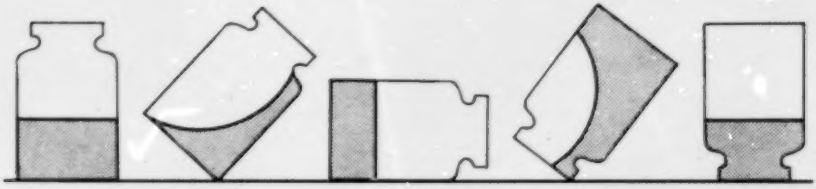
For example, in one experiment, children were shown a bottle that was one-third to one-half filled with colored liquid and placed on a table top. The children were asked to depict the line of the water in the bottle as the bottle was rotated to several discrete orientations. (The level of the water line shifts depending on the degree of tilt, but the line always remains horizontal or

parallel to the table top.) The overall pattern of results is summarized in Figure 2, which depicts four stages in development.

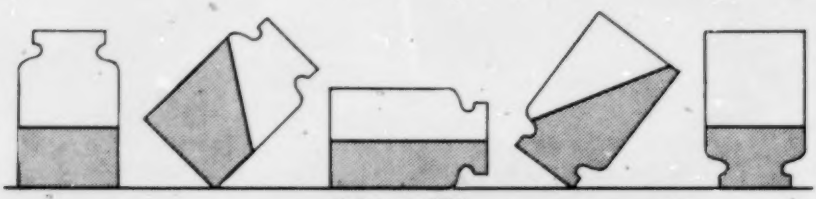
Piaget and Inhelder argued that this task required the child to relate a mobile element (the liquid surface) to a stable frame of reference outside of the bottle (the table top). Thus, it required the concrete spatial operation of mentally coordinating the elements of a changing relation. It is not until substage IIIB (ages 9½ to 11 years) that children can do this successfully for each of the



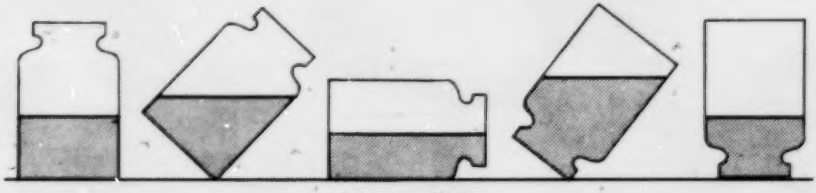
Sub-stage IIA



Sub-stage IIB



Sub-stage IIIA



Sub-stage IIIB

Figure 2. Stages in Development of the Horizontal Axis

bottle's orientations. Notice the intermediate stage in which children can correctly depict the water line when the bottle is placed horizontally or vertically on the table but fail when it is placed in a diagonal orientation. They err by drawing the water line parallel to the bottle's base. Lacking a stable concept of the horizontal, they are forced to rely upon cues inside the bottle. Given these kinds of results, Piaget and Inhelder concluded that it is not until late childhood that children can successfully represent or order space with stable horizontal and vertical axes.

A Comparison between IQ and Piagetian Assessments of Intelligence

Over the past 20 years, there has been considerable interest in the "psychometrization" of Piaget's clinical method for diagnostic use in the classroom. The reader will find a discussion of this issue in Green, et al. (18) as well as in other articles that address the relation between IQ tests and Piaget's measures (5,7,13). Some of the points raised in these papers will be reviewed here. Also, a brief annotated bibliography pertaining to Piagetian theory and testing is presented in Appendix B.

It is generally agreed that IQ tests and Piaget's assessments are based on different assumptions and have different objectives. It is not surprising, then, that empirical studies of both types of tests administered to the same subjects have found that they load on separate factors and generally show only a small positive relationship (5). For these reasons, if the content and objectives of our school curricula remain unchanged, there seems to be no valid reason to substitute Piagetian measures for IQ measures as predictors of school performance (18).

IQ measures were developed to predict scholastic performance. As such, it is assumed that scholastic performance is a valid criterion for intelligence. It is also assumed that intelligence is something that individuals possess to a greater or lesser degree, with the person who obtains a greater number of correct responses than his peer of the same age being judged as more intelligent. Presumably, differences in intelligence are due to the interaction of genetic and environmental factors. Items on IQ tests were not chosen on any theoretical basis but, instead, were screened on an empirical basis.

Piaget's view of intelligence contrasts point for point with the above psychometric view. Piaget has not been interested in the norm-referenced approach of specifying whether or not one individual is different from another in the amount of intelligence he or she possesses. Instead, he has attempted to study the general characteristics of intelligence that all humans possess. A Piagetian assessment locates an individual on a universal and invariant sequence of

development in which adult logical thinking is the criterion reference. From this perspective, intelligence is not something that individuals possess more or less of, and it is not a "third factor" caused by a heredity x environment interaction (13). (This point was discussed in the section on developmental construction.) Piagetian testing uses not only a subject's correct answers but also the type of errors made (5). Moreover, the wide age range in successful performance is probably not acceptable to psychometricians. On a particular task, success may improve with age in 5-to-10-year-old children, but a particular 5-year-old may show total success, and a 9-year-old may not, and both are considered normal.

In addition to the above considerations, it should be pointed out that it may be impossible to develop a universal psychometric Piagetian intelligence test. First, there is the question of which logical abilities should be included in the test. Should it assess classification, seriation, number concepts, or spatial concepts? Even if this question could be resolved, the next decision would be: Which items should be used to measure the abilities in question? For example, should the test of classification use fruits, animals, or flowers?

There are several aspects to this problem which render a culture-free test based on Piagetian assessments an impossibility. Performance of children and adolescents varies according to which items are used in assessment. For example, children can classify types of flowers before they can classify types of animals. Adolescents are more successful with tasks measuring combinatorial abilities than they are with tasks measuring proportional reasoning, even though both are formal operational in nature. Moreover, children's performance varies with the mode in which test problems are presented. Finally, as Piaget (18) has pointed out, his data presuppose a certain degree of activity on the part of the child being tested. This raises the question of how much time to set aside for each item on the test. Any decisions as to standard cut-off times will be arbitrary because some children will be penalized more than others, depending on the content and items chosen. For these reasons, the standardization of Piagetian assessments so that they are appropriate for all children (that is, culture-free) may not be possible.

Implications of Piagetian Assessments for Education

The above discussion has summarized differences between IQ and Piaget's measures of intelligence. Despite these differences, there are uses for Piagetian assessments in current classroom practice (2). One pertains to curriculum content. One focus of primary school education is mathematics, and Piaget has devised several tasks to measure mathematical thinking. These might serve as supplemental curricula. (The use of Piaget's measures to "grade" children

would violate the assumptions and purpose of the tasks.) In addition, there are many areas of logical thinking that Piaget has studied that are not currently included in primary school curricula. These areas, which are basic to mathematical and scientific thinking, include seriation, transitive inference, classification, class inclusion, and so on.

Perhaps another, more important, use of Piagetian measurement in classroom practice would be as a diagnostic tool (2). Teaching could consist of a two-step process of diagnosis followed by instruction. For example, a teacher who is supposed to teach her class addition facts might do well to consider each student's understanding of number. That is, she might assess each student's ability to conserve number. No doubt there would be some children at each of the three levels Piaget described and identified. The teacher might then devise different kinds of instructional activities for children at each of these levels, with memorizing tables used only for children with stable number concepts.

The point is that it may be meaningless, from the child's perspective, to teach children material that is beyond their present level of cognitive development. Hence, the suggestion is that Piaget's theory calls for a sequencing of curriculum content (2), and Piagetian assessments can help the teacher develop such a sequence. On the negative side, note that this would be a cumbersome process, since each child would have to be assessed in each content area; a child who is preoperational with respect to classification might be concrete operational with respect to number conservation, and so on. Moreover, since valid, group-administered measures of these concepts have not yet been developed, this suggestion is currently impractical in most settings.

IMPLICATIONS OF PIAGET'S THEORY IN EDUCATIONAL PRACTICE

Overview

Currently, there is widespread agreement that Piaget has identified principles of cognitive development that are relevant, if not critical, to educational practice (1,2,7,12,15,26,47,48,49). To date, however, there is still not a single Piagetian school or dogma. This is attributed to the fact that Piaget has claimed that he is not an educator and therefore has not detailed how to translate his findings into classroom settings (2). As a consequence, the few programs that have been developed vary as to curriculum content, teacher strategy, overall objectives, and so on, although each is labeled "Piagetian" (26). Recently,

Gruber and Voneche have asserted that this state of affairs is healthy and have suggested four possible types of Piagetian schools (19).

No doubt there are benefits to be derived from alternatives in educational practice. However, the present lack of consensus on even a theoretical level is confusing to the newcomer who is searching for *an* alternative approach to current methods. So before reviewing the implications of Piaget's theory for education, let us first consider why there is not a unitary Piagetian school. That is, why is there not one kind of classroom that is a logical consequence of Piaget's work? No doubt a large part of the answer lies in a point we have already discussed. That is, the implications of this theory for pedagogical application have not been consistent or uniform because the theory and testing techniques have changed over 60 years of research with children. Moreover, Piaget has studied and written about biology, philosophy, and epistemology, as well as education and in addition to his studies on cognitive development.

Given this fact, there are several reasons for disparate educational implications. (1) Two programs may be labeled "Piagetian" even though one does nothing more than introduce Piaget's assessments while another adopts a particular teaching style or strategy based on the theory (26,48). Thus, two programs could be based on aspects of the theory that do not directly overlap as far as application is concerned. (2) Two programs may differ even though each claims to be based on theoretical principles. This could be the result of misinterpretations or alternative interpretations, but could also occur if one program developer relied on Piaget's early works while another stressed more recent writings. One program would be based on the need for cooperative peer social interaction and perhaps stress the role of language. Another might have children solve problems individually, with problems geared to "their level." Still another program might be a combination of these two approaches. (3) Many of the theory's explanatory constructs are not, or have not been, subject to controlled or experimental testing in psychological or educational research. For example, the self-regulatory process of equilibration is considered the single most important factor in the development of knowing structures. Even if one were convinced that such a process exists, there are probably several alternative ways to capitalize on its effects in the classroom. So two programs may differ even though each claims to be based on the same theoretical principle.

It is hoped that the lack of consensus on ways to apply Piaget's theory will be resolved in the future by systematic educational research that shows that certain Piagetian programs do lead to positive results.* Given the many alternative interpretations or ways to apply Piaget's work, it is of great interest to review what Piaget himself has written about education. For this reason, the

*See Lawton and Hooper (26) for a review of existing Piagetian early-childhood-education programs.

following review of what education can, or perhaps should, do in light of Piaget's theory will rely heavily on Piaget's own educational statements (35,36,39).

The Need for Research

The reader will recall that Piaget became disenchanted with philosophy because of the nonempirical nature of its methods. Given this orientation, it is not surprising that one of Piaget's recommendations for education is to address the need for basic research. Two specific points have been made in this regard.

(1) Piaget has criticized the field of education for its ignorance of results of its own practices because of lack of research. For example, Piaget is particularly critical of the unchecked use of final examinations in secondary and higher education. Apparently, administration of exams presupposes that learning would take place at a minimal level, or not at all, without the exams. Piaget points out that under the present, supposedly effective, system we still do not know, after people have been out of school for 5, 10, or 20 years, how much they retain of knowledge acquired in school. If it could be demonstrated that most people have retained very little of their school learning, then in what sense are they educated?

With regard to evaluations of curricula or teaching strategies based on test results, Piaget points to the dangers of making decisions solely on empirical grounds. Programs with no theoretical rationale will probably continue to be effective for only a short period of time. Piaget compares education to seventeenth-century medicine, which applied methods on the basis of empirical results without knowing why they worked (38). Medicine today still does this to some extent, but is now firmly grounded in basic research in physiology, biochemistry, and so on. Piaget argues that education needs to be anchored in facts and theoretical principles of child psychology. Even here, however, Piaget's strong conviction in the primacy of research surfaces again.

(2) Piaget does not think that education should endorse child psychology in an unchecked manner. As early as 1932, he wrote:

> But pedagogy is very far from being a mere application of psychological knowledge. Apart from the question of the aims of education, it is obvious that even with regard to technical methods it is for experiment alone and not deduction to show us (which method is) of any real value. For after all, it is one thing to prove that cooperation in the play and spontaneous social life of children brings about certain moral effects, and another to establish the fact that this cooperation can be universally applied as a method of education. This last point is one which only experimental education can settle. Educational experiment, on condition that it be scientifically controlled, is certainly more instructive for psychology than any

> amount of laboratory experiments, and because of this, experimental pedagogy might perhaps be incorporated into the body of the psycho-sociological disciplines. But the type of experiment which such research would require can only be conducted by teachers or by the combined efforts of practical workers and educational psychologists. And it is not in our power to deduce the results to which this would lead (30, p. 406).

The need for pedagogical research, then, is perhaps the most important implication of Piaget's theory for education. As the above quote indicates, recommendations based on psychological theory should be verified outside the laboratory in practical settings.

It is not surprising that Piaget calls on the field of education to conduct basic research. In an earlier part of this paper, "Sixty Years of Research," changes in Piaget's theory were described. Recall that Piaget refined and substantially altered his theory in light of research results. He calls on education to modify its methods and objectives based on its own research. This brings us to another fundamental educational issue raised by Piaget: the importance of changes in teacher training.

Teacher Training and Team Research

Piaget is quite explicit concerning teacher training. He believes that full university training for teachers at all levels (especially primary) is essential. This training should focus on research proposed and developed by the teachers themselves in mobile, interdisciplinary settings run by sociologists, psychologists, and educational researchers. Thus, Piaget argues that the dichotomy of classroom teacher-educational researcher should be eliminated. He points out that reforms in educational methods will need to be implemented by the teachers, and the better the method, the more demanding will be the role of the teacher. Notice that the type of teacher training Piaget calls for is quite radical. Teachers should not only attend graduate-level lectures (on Piaget's theory, for example), but in order to attain a true understanding of their students, they need to conduct psychopedagogical research.

This recommendation of doctoral-level education as prerequisite for all teachers is economically prohibitive in that teacher pay scales would have to be increased. However, this is precisely what Piaget has in mind, for he feels that there is a grave social problem in our (western) society in that the teaching profession is a low-status one. The public underestimates the value of our children's teachers, and their low status is at least a partial consequence of current methods of certification. Piaget believes that it is by and through research that the teaching profession will cease to be merely a trade and acquire the dignity it deserves (35,40).

The above recommendations of a need for research and for teacher training and team research were general in the sense that they were based more upon Piaget's philosophy than on his theory of cognitive development. The following recommendations stem from considerations of what Piaget's theory posits about the intellectual growth of children.

Educational Objectives

Piaget's theory can give education a goal. Schools can attempt to nourish and enrich the development of children's thinking instead of only teaching specific facts and skills in a manner that treats all children the same way. In other words, schools can stress development rather than learning. The intelligence of all normal children will grow and change qualitatively from birth to adolescence. The source for this development lies within all children, and our schools can make use of it by providing a climate for thinking instead of learning, which is often at too high or too low a level. The reader will find a more complete discussion of educational objectives in light of Piaget's theory in Furth and Wachs (15), Lawton and Hooper (26), Elkind (7), and Sigel and Cocking (48).

The objective of focusing on the child's spontaneous intellectual development raises several issues with respect to classroom practice. A few of these issues are considered in the following pages.

Teaching Methods

In 1965, Piaget (35) asserted that the cardinal problem of pedagogy in 1935 and in 1965 concerned teaching methods. Should teaching be a process of transmission of knowledge from teacher to pupil, or should teaching give the child the opportunity to reconstruct or reinvent knowledge? Piaget, having rejected an empiricistic view of intellectual development, rejects an empiricistic view of education as transmission of information. He points out that one should not assume that educational transmission (teacher talking to the class) supplies the child with the instruments of assimilation simultaneously with the knowledge to be assimilated. Recall our example of number conservation. If a child has not yet constructed a stable concept of number, even the clearest lesson or textbook on addition will not be of help. The instruments of assimilation (schemes or operations) cannot be acquired except by means of internal activity on the part of the child. Piaget is arguing that educational transmission is only one factor in intellectual development and is subordinate to internal self-regulation. Hence, Piaget opts for a classroom that allows for

reconstruction of knowledge, and such a classroom usually relies on "active" methods.

Before discussing what active teaching methods might entail, we need to consider where they might be expected to be effective, for Piaget has been cautious in this matter. The statement has been made that schools can focus on the changes and growth in intelligence that occur in all children. Specifically, they can focus on development instead of on rote learning, especially in the early grades. This objective needs some qualification.

Piaget's research has shown that certain content areas are spontaneously constructed by our human intelligence and are not dependent upon the individual decisions of adults. Some of these content areas, such as mathematics and understanding of physical laws, are indeed taught in the schools. Piaget's statements pertaining to reconstruction of knowledge via active methods in the classroom are meant for these areas of overlap. Piaget has recognized that there are other areas that have been developed by adults that are *not* spontaneously constructed by children. Psychologists still do not know the mechanisms that give rise to understanding in these areas (such as foreign language, spelling, and historical facts). Hence, for the present, these areas may still need to be transmitted from teacher to child (with better or worse information techniques) since they are not universal constructions.

To settle the matter of teaching methods for the latter subject matters, Piaget has again called for more research. It is still an open question as to whether solutions for teaching methods in these areas will resemble solutions in other areas (3,28).

As far as Piaget is concerned, then, the potential scope of Piagetian teaching methods still needs to be delimited and verified. Thus, in his statements on specific educational recommendations, Piaget has addressed himself mainly to mathematics (39) and to science teaching (40), the areas we all "construct" regardless of classroom experience. Hence, Piaget is more cautious than some of his interpreters who argue for the usefulness of his methods in all areas of thinking and instruction (15).

What follows, then, is a recap of Piaget's recommendations to address one of our current educational problems—the need for a higher proportion of students to elect courses in the sciences. Piaget's recommendations for science teaching focus on "active" methods, but these vary with the level of the students. At the preschool level, children can be assisted in increasing their powers of observation, for they are particularly poor at reporting what they have just observed or have just performed.

Piaget points to a need, at the grade-school level, for education to bridge the gap between qualitative structural development and quantitative formulations. The spontaneous and universally developed qualitative structures ought to constitute the foundation of elementary school instruction in science. The

problems that arise are not due to differing science aptitudes (Piaget has not observed any such differences in the concepts he has investigated) but to the too-rapid passage to quantification without basic qualitative understanding. Piaget asserts that it is not science that the students do not understand but the lessons of science. They have difficulty adapting to the type of instruction, and perhaps new means of instruction would help in this regard.

Finally, at the high school level, Piaget argues that all students need to be introduced to experimental procedures. Since the intellectual structures necessary to conduct experiments are formed during early and middle adolescence, Piaget is again urging that we focus on the development of thought. Students should not merely be presented with science facts but should be asked to prove them on their own. Naturally, our objectives and methods of evaluation would probably change as a result. The day-to-day work would have to be observed and recorded. This record of performance over time would supplement, if not replace, evaluations based on exam performance. No doubt such an approach would not only nourish intellectual development but also help identify students with a "bent" for science.

Piaget's recommendations for science teaching rely on active methods. He points out that the role of the teacher is crucial, for it is up to the teacher to organize and to present situations that are useful to the child. Children in an active classroom do not "do their own thing" (cf. Furth & Wachs "freedom within structure" concept). Moreover, in higher grades in particular, an active approach will sometimes entail reading and thinking at a desk as well as overt actions on concrete objects or problems. The shift to learning through reading should be a natural consequence of intellectual development in late childhood and early adolescence when the mechanisms that enable the child to profit from this mode of instruction have been developed.

At all levels, then, an active classroom needs a well-trained teacher. The teacher should be not only a lecturer but a mentor who stimulates students to experiment by providing counterexamples that compel reflection. Piaget points out that given the fact that it took thousands of years to develop certain mathematical notions, it is absurd to assume that without guidance toward awareness of central problems the child would ever succeed in formulating them himself. Thus, we return to the fact that Piaget's recommendations for educational practice center on teacher training to produce researchers who understand not only their subject matter but also their pupils.

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APPENDIX A
HOW TO CONDUCT PIAGETIAN CHILD ASSESSMENTS

This section provides a guide to assessing children's thinking, using tasks developed by Piaget and his collaborators. Differences between norm-referenced IQ tests and Piagetian assessments are outlined in other sections of the paper. We have seen that IQ test items were not chosen on the basis of any theory of child development and are, therefore, somewhat arbitrary. Piagetian assessments, on the other hand, were developed according to the view that knowledge is a developing relation between knower and known object. Intellectual development is a process of constructing schemes and operations (coordinations of actions) that confer meaning.

The motivation for this process of development is a biological self-regulatory one that is found in every child. Thus, in theory, Piagetian assessments should be appropriate for all kinds of children. To date, research findings support the theory. A good illustration of the utility of Piagetian assessments comes from Furth's work with congenitally deaf children and adolescents (10). Furth translated Piagetian tasks into nonverbal forms and found that deaf children attained logical, concrete-operational thinking by early adolescence. Thus, coordination of actions does not depend on sophisticated use of societal language.

The fact that children understand the world in qualitatively different fashions during different developmental periods is now widely accepted. Piagetian assessments were formed with this view of children in mind. They allow the assessor to uncover the child's conception of objects and events in the world. This section will help you to learn how to conduct these assessments of children's thinking. A word of warning is in order. Before you actually sit down and work with your first child, there is a great deal of preliminary preparation required. We will begin with this aspect of conducting assessments.

Preliminary Preparation

I suggest that you start by reading Piaget's original description of the task you are interested in. For example, if you want to assess children's understanding of number, look for tasks described in *The Child's Conception of Number*. If you want to assess children's understanding of the horizontal coordinate using the water-bottle apparatus, read Chapter XIII of *The Child's Conception of Space*.

There are several reasons for going back to Piaget's descriptions. First of all, if you are interested in conducting Piaget's assessments, there is no substi-

tute for reading Piaget and the protocols he presents to describe his procedure and results. In reading Piaget's descriptions, you will discover that he almost always used several sets of materials and procedures when working with children. You will probably be surprised at the number of ways he sought to check and double-check results with alternative procedures. In all likelihood, several readings of the chapter will be necessary before you get a feel for what Piaget did and what he found. Quite often, alternative or secondary procedures are not described in enough detail to make replication possible. In these cases, I suggest that you rely on the main procedure, which should be sufficiently detailed in the text to permit replication.

What about commercially marketed tests and curriculum materials that purport to be Piagetian assessments? These materials are not of uniform quality, varying greatly from one to the next. It is therefore difficult to summarize their usefulness and appropriateness. Some are excellent and can save you some time, but many others grossly misrepresent Piaget's original work and assessment technique. Obviously, just using the label "Piaget" does not render the material consistent with Piaget's methods and purposes. The only way to be sure that you are conducting the assessment properly is to check for yourself by reading the original experiments. Although the process of reinventing Piaget's assessment techniques is tedious at first, the payoff is a deeper appreciation of these techniques and ultimately of the theory itself.

Compiling Materials

For the most part, fancy equipment is not needed to conduct Piagetian assessments of children's thinking. You should be able to compile the necessary materials on your own. However, if you plan to assess all the children in a classroom, you will also need data sheets to record your observations.

The importance of carefully constructed data sheets cannot be overemphasized. These sheets can serve as your guide during the assessment session and will also serve as your record of results after testing is completed. The data sheet should have a descriptive title and should have blanks for the child's name (or initials), sex, grade, birth date, and testing date. The major portion of the sheet should present the sequence of trials, ordered correctly, in *pictorial form*. There should also be room for you to record the child's verbal responses to your probes. (If you are conducting a verbal interview only, you will probably need a tape recorder.) The pictorial or schematic depictions show you how to arrange your materials for each trial and should be in enough detail so that you can pencil in what the child actually did. Boxes for assigning "stage scores" may be included but only in addition to these other aspects. You are not making the best use of your time if you simply record a child's

stage of performance when conducting assessments. Instead, try to capture what the child did and said in each trial. Later on, when you are reviewing your results, you can assign stage scores if that suits your purposes.

The final aspect of preparation is to practice the assessment procedure from beginning to end until you are comfortable with it. You may want to practice with adults at first, and then try it with one or two children. Make sure that you can go back and forth from setting up the material and posing questions to recording responses on the data sheets. Settle upon one or two sets of questions for each trial, and then use them when you see the rest of the children. If your data sheets have been properly constructed, this practice will free you from memorizing the arrangement of materials and verbal probes.

Examiner's Assumptions and Goals

Now that you are ready to begin, let us discuss your assumptions, expectations, and frame of mind. Your goal in conducting this assessment is to uncover the child's best level of performance. You are after the how and why of the child's thought and not so much what he or she knows. Thus, you do not have to impose rigid time constraints, you may repeat questions, you may even "start over," and so on. You are not testing children in the same way that you would with a classroom exam. That is, when you have completed the assessment, you will not have the kind of data that would allow you to say, "Jane is slow and Jenny is ahead." Instead, you will be locating Jane and Jenny on a universal continuum in which logical adult thinking is the criterion reference, a goal both children can reasonably be expected to attain eventually. Try to remember that with Piagetian assessments, it is the children's *concepts*, not the *children*, that are "in stages." For example, Jane can be preoperational with respect to conservation of continuous quantity but concrete operational with respect to conservation of number.

Conducting the Assessment

Most Piagetian assessments necessitate working with one child at a time. The session should be conducted in a quiet room that has been set up for your assessment. Begin by introducing yourself to the child and stating your objectives for the session. You may present the procedure as a "thinking game" and ask the child to try his or her best. In a one-to-one setting, almost all children will respond to this request, especially if you are relaxed and emphasize their participation and not their performance. The child will take cues from you, so if you are relaxed and at ease, you will increase the likelihood that the child

will also be at ease. (Unfortunately, if you are the child's parent or classroom teacher, he or she may not be able to relax with you as an examiner or may be too relaxed and not attend to the task at hand. If at all possible, work with children you do not know too well. Perhaps you and a colleague can trade classes.)

Once you have obtained the necessary face-sheet information and feel that the child is ready, start the assessment procedure as you have practiced it. Depending on your purposes, it may or may not be all right to provide the child with feedback as to the correctness of his answers. You can always respond by saying, "All right, that's very good. Now let's try another game [or problem]." Use the probes and counterprobes presented by Piaget. Feel free to challenge the child's answer even if it is correct. For example, in assessment of conservation of continuous quantity: "You said that this glass holds more to drink. Yesterday, a girl named Sue, who is your age, said this [other] glass holds more to drink. Was Sue right? How come?" When you have completed the assessment, thank the child for his or her participation and ask which parts of the game were the most fun.

Pragmatic Considerations

If you are going to test a large number of children, keep the following points in mind. (1) After a while, the sessions will become repetitive for you but they will remain novel for each child as he or she enters the room and begins the assessment. You will be very familiar with the procedure, but the child will be totally unfamiliar with the procedure and task at hand. You must try to be as enthusiastic with the last child you observe as you were with the first. (2) Because of the above, do not plan too much testing for one day. It is better to spread the testing time over several days than to test a large number of children in a shorter period of time. Examiners have individual paces and endurance levels. After a day or so, readjust your plans so that the schedule remains comfortable and realistic for you. (3) In addition, remember that each child works at his or her own pace. When conducting the assessment, you will have to adjust for individual differences in speed of responding. In general, younger children will require more time to complete the assessment than older children, so if you are testing children of different ages, you should plan accordingly.

APPENDIX B

PIAGETIAN THEORY AND TESTING: A BRIEF ANNOTATED BIBLIOGRAPHY*

Elkind, D., Two Approaches to Intelligence: Piagetian and Psychometric. In D. R. Green, et al. (Eds.), *Measurement and Piaget,* New York: McGraw-Hill, 1971.

The Piagetian and psychometric approaches to intelligence are similar in that they both acknowledge the importance of genetic factors in intellectual development, employ nonexperimental methodology, and conceive of intelligence as essentially rational. The two approaches to intelligence differ in (1) the type of genetic causality they presuppose—random selection factors for psychometric versus nonrandom organizing factors for Piaget, (2) the descriptions of mental growth they provide—a quantitative, age-normed curve depicting amount of intelligence for psychometric versus an age-related pattern of qualitative differences in intellectual structures for Piaget, and (3) the contributions of nature and nurture that they assess—a static view of intelligence as a measurable construct in which measurement can assess the relative contributions of nature and nurture versus a dynamic view of intelligence as relatively autonomous from environmental and instinctive influences. The paper closes with a discussion of practical issues; the implications of Piaget's conception of intelligence for preschool instruction, for motivation and mental growth, and for the assessment of intelligence.

Elliot, C., The Measurement of Development. In V. P. Varma & P. Williams (Eds.), *Piaget, Psychology and Education.* Itasca, Ill.: F. E. Peacock Publishers, Inc., 1976.

The relation between theory and measurement as well as definitions of development are discussed. Careful observations are a necessary precursor to measurement. The difficulties in constructing standardized tests to measure Piagetian developmental stages are reviewed. Objective developmental measures require: (1) sample-free estimates of an individual's ability, (2) test-free estimates of an individual's ability, (3) ratio scaling, or at least interval scaling, of abilities, and (4) the construction of measurement scales that can span the entire age and ability range for which a test is designed. Extant norm-referenced tests of cognitive ability are inadequate to measure development since they

*In several instances, the bibliography contains excerpts from the author's original work.

possess none of these features. A more appropriate model is the one proposed by Rasch. Preliminary data from the British Intelligence Scale project, which used the Rasch model, are discussed with respect to the above four requirements. It is concluded that Rasch's model for item and ability scaling holds promise for future work in constructing objective measures of development.

Furth, H. G., Piaget, IQ and the Nature-Nurture Controversy. *Human Development*, 1973, *16*, 61-73.

The contributions of heredity and environmental experience to intellectual development as defined by Piaget are discussed. The relation between Piaget's definition of intelligence and an IQ definition is reviewed. In Piaget's theory, intelligence is not a separate, third factor resulting from the interplay of heredity and environment. Moreover, Piaget would question the following four assumptions inherent in the standardized IQ test approach: (1) age constancy, (2) scholastic validity, (3) standard environment, and (4) performance sufficiency. Piaget's theory can address individual differences in intelligence and offers a fruitful approach to the study of the intellectual abilities of special children. Piaget's developmental constructivist approach to intelligence is incompatible with approaches that assign a score that purports to show innate potential or the general ability to learn.

Gray, W. M., A Comparison of Piagetian Theory and Criterion-Referenced Measurement. *Review of Educational Research*, 1978, *48*, No. 2, 223-249.

Currently, educators are employing either criterion-referenced measurement or tasks based on Piaget's theory to assess human mental functioning. The origins of the two approaches are reviewed and then they are compared with respect to the following: (1) conceptions of change, (2) item placement, (3) subject variance, (4) cognitive structures and an achievement continuum, (5) reasons for a response, and (6) performance to be assessed and performance criteria. It is concluded that the two approaches are compatible and should be conjoined in test construction in order to have tests that indicate not only content mastery but also cognitive level. Such tests would be of great assistance in individually oriented curricula.

Neimark, E. D. On the Measurement of Formal Operations. *The Formal Operator*, 1978, *1*, No. 3, 10-11.

Currently, there is dissatisfaction with existing measures of formal-operational thinking. One of the impediments to construction of better measures of formal

thought is the almost exclusive use of the Inhelder tasks. There is evidence that these tasks are noisy and inefficient. Group-administered paper-and-pencil tasks may simply translate the original tasks into modified and inappropriate forms. A sound theoretical rationale for the construction of formal-operational measuring instruments is needed. Perhaps the Binet model for test construction could be used to assess the extent and generality of formal-operational skills. On such an instrument, a basal level of performance would be established, with successive items designed to assess the breadth and depth of application beyond the basal level. Separate scores for these separate aspects could be recorded.

Pinard, A., & Laurendeau, M., A Scale of Mental Development Based on the Theory of Piaget: Description of a Project. In I. J. Athey & D. O. Rubadeau (Eds.), *Educational Implications of Piaget's Theory*. Waltham, Mass.: Ginn-Blaisdell, 1970.

This paper introduces a project that had two major objectives: (1) to attempt to replicate Piagetian stages in a non-Genevan population using a more rigorous and uniform methodology than the original work, (2) to construct an ordinal scale of development applicable to children aged 2 to 12 years. Seven hundred French Canadian children from the Montreal region were individually observed on 24 tests of sensorimotor coordination, 8 tests of verbal comprehension, and 25 Piagetian tasks (total of 57 subtests and 300 items). On the whole, results of preliminary analyses confirm the existence of Piaget's stages, although the age of onset was slightly higher for this population. It is concluded that the results of a normative study of cognitive growth based on Piaget's theory are potentially useful to educators in that they help uncover the origins and development of fundamental notions involved in school learning and in that they may assist in the refinement of curriculum development and teaching methods.